Editorial

Ajith Parlikad

Professor, Institute for Manufacturing, University of Cambridge,
Cambridge, UK

The past decade has seen rapid advances in digital technologies including internet of things, cloud computing, machine learning, data analytics and artificial intelligence techniques that can radically transform the way we manage our infrastructure. In this context, the concept of digital twins – which aim to replicate the state, status and behaviour of infrastructure assets in the digital world through effective integration of data, models and decision-support systems – promise a step-change in productivity and sustainable performance. The key difference between existing infrastructure modelling tools (e.g. building information modelling (BIM), simulation models) and digital twins is the ‘connection’ that the digital twins have with their physical counterparts. This connection enables the digital twin to mirror the actual status of the physical asset as closely and as timely as necessary. More importantly, the connection also enables the digital twin to communicate actions back to the physical twin, thereby enabling closed-loop control.

Although the idea of digital twins has a history spanning at least a decade, the emergence of novel sensing/data-capture solutions, increasing computational power at ever-shrinking costs, and advances in statistical techniques have equipped us with tools that help make the realisation of digital twins of our infrastructure closer to reality. Digital twins can thus generate a deeper understanding of how complex infrastructure systems behave and perform, thus enabling us to manage them better. Nearly all the major vendors of modelling tools and enterprise information systems have launched products that claim to offer their clients the ability to develop digital twins of their assets. However, many such tools are either a repackaged offering of existing products or offer additional functionalities that do not yet achieve the goal of digital twins. A number of challenges need to be addressed in order to make the vision of digital twins a reality.

The academic and practitioner communities have been active over the past few years with cutting-edge research on addressing some of the major challenges in the design, development and deployment of digital twins. This themed issue brings together three interesting articles that takes the reader through the journey of defining, deploying and extracting value from digital twins.

The first step in designing any digital twin is therefore to determine the data and information it should hold regarding the physical asset. Although there are a number of standards relating to infrastructure data management (e.g. ISO 19650), there is a lack of guidance on how to define the ‘asset information requirements’ in a systematic manner. In the first paper of this themed issue, Johnson *et al.* (2022) presents a methodology for defining the asset information requirements ensuring a clear line-of-sight with the organisational objectives. This practical

approach is tested and demonstrated using a real industrial case study based on the rail infrastructure.

Once the information requirements are defined, it is necessary to think about an appropriate architecture that defines the key components of a digital twin, the communication mechanisms between the physical assets and their digital counterparts, the data schemas, models and storage solutions used to manage the data, and the tools and algorithms that analyse and interpret the data to drive improved operations and management of the asset throughout its lifecycle. In the second paper of this themed issue, Lu *et al.* (2022) review the current approaches and standards for asset lifecycle data management and presents a framework for creating a blueprint of an infrastructural digital twin.

Every digital twin must have a purpose. The purpose of a digital twin is to deliver value to the asset’s stakeholders by supporting their decision-making and by driving actions that enable the asset to perform in an optimal manner. In order to deliver value, digital twins often require models that reflect the behaviour of the physical asset and predict its performance and condition based on the data captured. Approaches that merge data-centric and physics-based models are becoming increasingly popular in this context. In the third paper of this themed issue, Jafari *et al.* (2022) present a novel architecture of a digital twin that brings together real-time data from sensors and building management systems, contextual data from BIM and simulation models to improve the energy footprint and asset management of buildings. The paper explores how such an approach can reduce cost of operation as well as improve the comfort of the occupants of the buildings.

The three papers in this themed issue therefore effectively provide a storyline and blueprint of how digital twins can be designed, deployed and utilised to generate value for the stakeholders of infrastructure assets and systems.

REFERENCES

- Jafari MA, Ghofrani A, Zaidan E and Abulibdeh A (2022) Improving building energy footprint and asset performance using digital twin technology. *Proceedings of the Institution of Civil Engineers – Smart Infrastructure and Construction* **174**(2): 57–65, <https://doi.org/10.1680/jsmic.21.00001>.
- Johnson A, Heaton J, Yule S *et al.* (2022) Informing the information requirements of a digital twin: a rail industry case study. *Proceedings of the Institution of Civil Engineers – Smart Infrastructure and Construction* **174**(2): 33–45, <https://doi.org/10.1680/jsmic.20.00017>.
- Lu Q, Xie X, Parlikad AK, Schooling JM and Konstantinou E (2022) Moving from building information models to digital twins for operation and maintenance. *Proceedings of the Institution of Civil Engineers – Smart Infrastructure and Construction* **174**(2): 46–56, <https://doi.org/10.1680/jsmic.19.00011>.